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The day the 2003 European heatwave record was broken



On June 28, 2019, a temperature of 45.9°C was recorded at a weather station in France, exceeding the country's previous temperature record—set during the infamous 2003 heatwave—by almost 2°C. The heatwave peaked over central and northern Europe, fuelled by a very persistent planetary-scale Rossby wave (giant meanders in upper-tropospheric winds), which turned into an omega block, so named because its shape resembles the Greek letter (Ω). This blocking event led to hot air from northern Africa being transferred to Europe (figure).¹ Given the extraordinary nature of this event, the public and media are now wondering: is such weather the new norm, and how bad could it get in the future?

Although heatwaves have always occurred as an intrinsic part of our weather, strong evidence suggests that their frequency and magnitude are increasing because of anthropogenic climate change,² and the 2019 event is no exception. Heatwaves are initiated by weather patterns, and atmospheric patterns similar to those responsible for this temperature record have been identified in many of the major European heatwaves observed over the past 20 years.³ These patterns often result in stationary high-pressure systems over western Europe. For instance, the simultaneous heatwaves over much of the northern hemisphere in the summer of 2018 happened during the occurrence of a high-amplitude and stationary Rossby wave, locked in position and likely to have been further reinforced by latent heating from dry soil regions.³ A detailed analysis of the 2018 event concluded that it was “virtually certain” that the heatwave was enhanced by human-induced climate change,⁴ which prompts the question of whether such a statement applies to all factors that influenced the event. For instance, clusters of persistent high atmospheric pressure (ridges) have been observed over Europe over the past two decades, possibly explained by a slow-down of the mid-latitude summer circulation. However, projections showed that associated blocking is unlikely to change in the future based on traditional blocking metrics.⁵ Thus, the attribution of such circulation changes to anthropogenic greenhouse gases is still under investigation, but, either way, changes in heatwave statistics are probably being driven mainly by the background thermodynamic response of the atmosphere.

The climate has warmed by around 1°C globally to date since pre-industrial conditions;⁶ however, land areas,⁷ particularly urban regions, are warming faster than the oceans, and the locations most relevant to human populations are therefore being more exposed to heat stress than this global average temperature increase implies. No event made this more apparent than the July–August 2003 heatwave, which saw around 15 000 heat-exposure-related deaths in France, and around 70 000 deaths across Europe.⁸ Climate change had

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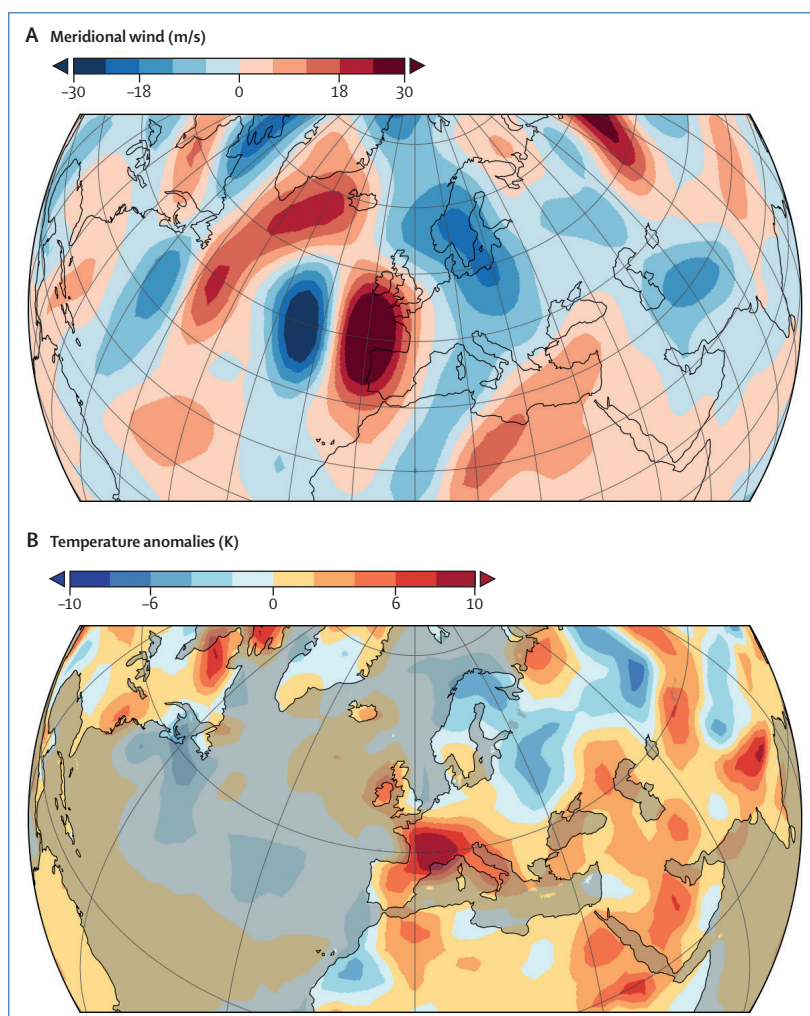


Figure: Atmospheric circulation and near-surface temperature anomalies during the June 2019 heatwave in Europe
A high amplitude Rossby wave train emerges on June 22, 2019, and turns into a persistent omega-block over western Europe, leading to inflow of hot air from the south. (A) 3-day average meridional winds centred around June 27, 2019. (B) Daily averaged near-surface temperature anomalies for June 28, 2019, relative to 1981–2010 summer climatology (June–August). Data are from the NCEP–NCAR reanalysis 1 data set from the National Oceanic and Atmospheric Administration’s Earth System Research Laboratory.¹

a significant role to play in 2003, with 70% of the Parisian heatwave deaths attributed to human greenhouse gas emissions;⁹ yet asking the same question of the 2019 heatwave is less straightforward because the heat-mortality relationship is likely to have changed since countries have put in place better heat-response plans. Establishing the present-day heat-mortality relationship for each city requires daily information on different types of deaths, which is hard to collate on timescales of less than a year. As such, the only heat-related deaths we hear about at the time of the heatwave are those obviously associated with heat, such as those reported to be due to cold shock (a sudden change in heat [eg, from a hot beach to cold sea]) during the 2019 heatwave, or deaths in children left in overheated cars during the Chicago 1995 heat event. Therefore, although the extreme temperatures associated with the 2019 heatwave are tending towards becoming the new normal in terms of summer climate, it is less clear how this change will translate into human health. The deaths reported at the time will be a substantial underestimate of the true number, which will only become apparent in the coming months and years. These under-reported deaths will be mainly from cardiovascular or respiratory failure in older and at-risk populations, and such deaths are harder to immediately attribute to the heat.

On the question of how bad this situation could get in the future, all climate models project warming as atmospheric greenhouse gases increase, with mean projected global warming at the end of the century ranging from 2°C to 5°C above preindustrial values.⁶ This range is due to a combination of uncertainties in the emissions scenario and in model physics, especially those related to clouds. To elucidate how future climate change under the Paris Agreement might alter a 2019-like heatwave, we evaluated the probability of recurrence of such a heatwave over France using a set of global climate models specifically designed to study extreme weather.¹⁰ The 2019 heatwave is so extreme that our current models could not fully represent the observed temperature magnitude over France under current climate forcing, probably because of a misrepresentation of the soil-moisture feedback, which acts to enhance warming trends, especially in mid-latitude areas such as central Europe.¹¹

Although it is hard to model all the conditions that drove the June 2019 heatwave, the evidence is clear

that severe heatwaves will become more frequent as the climate continues to warm.² Future heat-related mortality will depend on country-specific adaptability and mitigation plans, as well as the future emissions scenario; even so, different climate models give different temperature projections, so mortality counts are uncertain.¹²

Unless we significantly reduce net greenhouse gas emissions, heatwaves will become more extreme in magnitude in the future, and human mortality will increase as a result, unless adequate heat-adaptation plans are put in place.¹³ The concerns implicit in the literature⁸ are that incorporation of long-term planning for heatwaves might not be occurring in some countries. Such frustrations to civil preparedness arise because of poor dissemination of climate science findings and inadequate data collection, and, perhaps, because health and climate researchers need to work together more closely, including sharing data.⁸ Immediately before and during heatwaves, planned responses often seem to be rather last minute or poorly constrained. This situation affirms the need for climate modellers to continue their efforts towards better understanding and predicting heatwaves, with the aim of providing earlier warning, where possible. We strongly recommend that these efforts should occur alongside tighter collaborations with medical practitioners, researchers, and local officials involved in the design of heat-action plans. Despite the record-breaking temperatures of 2019, the total number of heatwave deaths might be lower than those during previous events. If so, this difference will be partly because of the persistence of the heat, but—to give due credit—also down to improved emergency heatwave plans developed in reaction to the 2003 and other disasters. Hospitals in particular should prepare for patients with increased heat stress and associated physiological conditions. Crucially, if correlations between past heatwaves and associated mortality rates based on previous heatwaves predict more deaths than actually occur during 2019, it will provide encouragement that recent heatwave planning has been effective.

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We declare no competing interests.

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